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(54) **METHOD AND APPARATUS FOR PRODUCTION OF ICE-CREAM**
VERFAHREN UND GERÄT ZUR HERSTELLUNG VON SPEISEEIS
PROCEDE ET APPAREIL DE PRODUCTION DE CREMES GLACEES

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Description

[0001] The present invention relates to the production of ice-cream material and more specifically to a production method of the type, by which the material in the form of the so-called mix with a substantial content of air is first cooled down to a conventional forming temperature of typically -5°C and then brought further to a throughflow freezer, in which it is attempted to cool down the mass to a temperature of -15° or lower, preparatory to extruding the mass for the forming of the final ice-cream bodies for packing and final storing.

[0002] This 'type' of process is known from the literature, cf. DE-C-39 18 268, but not really from practice as far as usual ice-cream is concerned, since the process has been found to involve quite marked problems. At the principal level the process type is highly attractive, because ideally it would make it possible to form and pack the ice bodies directly to the final storing, without the conventional use of an intermediate and expensive low freezing system-between the packing station and the final storage. Moreover, an intensive cooling of the mass will enable an improved product quality, in particular when producing larger block products.

[0003] The direct starting point of the invention was a test system including a conventional throughflow freezer having a driven, scraping conveyor worm,. dimensioned for a further conveying of the flow from the preceding, ordinary continuous freezer, which cools the mass down to some -5°C. As the flow remains unchanged it was natural to select increased or unchanged pipe dimensions. At the outset, a standard mix of ice-cream with a so-called overrun (degree of swelling) of 100% was used, and in the throughflow freezer an evaporator temperature of approximately -40°C was used.

[0004] It was found rather soon that the achievable results were entirely unusable in practice. It was found that it was difficult to reach the desired low temperature of the ice-cream, and moreover the overrun was decreased quite unacceptably, down to 30-50 %. Changed process parameters made no difference in this picture, but demonstrated that the drastical drop of the overrun was noticeably influenced by such changes.

[0005] A solution of the said problem was made difficult by the fact that it was not - and still is not - possible to precisely indicate the reason why the overrun turns out to be decreased.

[0006] However, according to the invention a surprising solution to the problem has been found, viz. by introduction of a controlled resistance in the flow from the throughflow freezer. From a processing point of view this will not be any particularly attractive solution, but it will be attractive anyway as long as it seems to be the only possibility of making the discussed 'type' of process practically usable at all. Also, the said resistance will not in any way need to be so high that it will indirectly reduce the production. capacity to some commercially uninteresting level.

[0007] Thus, some additional energy should undeniably be used for the forcing out of the mass from the throughflow freezer, but this amounts to almost nothing in view of the . fact that in return the discussed type of process can then be used in practice for achieving a really usable result, i.e. providing a final product having the desired overrun, structure and low temperature.

[0008] It could be desirable that it would be possible to introduce as a simple measure the said delivery flow restriction as a permanent pipe narrowing, but the further efforts in connection with the invention have shown that this will not normally be sufficient, as the optimum constriction is depending not only of the mechanical process parameters, but also of the formulation of the mix and the relevant process parameters. In practice, therefore, it seems to be a necessity to use a controllable, variable flow resistance. This may be realized by the use of an adjustable throttling valve or pressure regulating valve or by the use of a controlled, partial heating of a narrowed discharge pipe.

[0009] In that the flowthrough freezer should operate with a heavy cold transfer at extra low temperature, there is currently formed, on the inside of the freezer, an ice layer which should be scraped off. As it is also desired to effect a positive conveying of the ice-cream mass inside the cylinder, there will be no technical problem in combining such a scraping and conveying, viz. in using a scraping worm conveyor, which is a known machine element. However, with a test system using such a known worm conveyor freezer the result is rather discouraging, as it is observed that in order to effect the scraping and the conveying of the ice-cream mass it is required to supply so much energy that the freezer becomes ineffective because of the applied scraping, kneading and pumping energy, which will reveal itself as a heat development, directly opposing the the freezing. This can be counteracted by using a furtherly lowered temperature on the cooling side, but only with the result that the building up of the said ice layer is promoted such that still more energy will be required for the scraping function, and it has been found that also this basic condition must be responsible for the discussed process 'type' not so far having been realized commercially.

[0010] On this background and in connection with the invention it has been considered whether it could be. possible to provide an entirely different and more effective throughflow freezer. Surprisingly enough, however, it has been found possible to maintain the relatively effective and simple concept of a worm conveyor, when only the traditional design thereof is drastically changed with respect to the rotation speed of the rotor and the pitch of the worm winding or windings.

[0011] For worm conveyors in connection with flowthrough freezers it is customary to use a rotor rotation at some 100-1000 r.p.m., least for larger cylinders and highest for cylinders with small diameter. For a representative worm conveyor with an inner worm diameter

of 105 mm the rotor speed will typically be 200-600 r.p.m. which, by a typical worm pitch of between a whole and a half time the outer diameter of the worm will result in an axial scraping speed of 1-3.5 m/sec.

[0012] With the invention it has been found possible and optimal to operate with a revolution figure of only some 5-20 r.p.m. as well as with a worm pitch that is unusually large, viz. between one to two times the outer diameter of the worm, preferably between 1 and 1 1/2 times this diameter. The said scraping speed will thus occur at a reduced value of only some 1-10 % of the conventional standard, but it has been found that in return it is then possible to realize the. process in practice. What is actual is a practically usable compromise between the effect of the applied energy being sufficient for conveying and scraping without causing undesired heating. It is a surprising result that the low scraping speed and the associated low scraping frequency is sufficient for keeping the heat exchanger surface clean to such an extent that it is possible to operate with a practically acceptable efficiency of the heat exchange.

[0013] It is even to notice that for good reasons it is required to use a refrigerant with an evaporation temperature lower than the approximately -30°C, which to the skilled persons has been considered as a minimum evaporation temperature in connection with continuous ice-cream freezers; it has previously been found that with still lower temperatures there will occur a too heavy solid freezing of the ice-cream on the heat exchanger surface. Apparently it is a paradox that with the invention and the associated reduced scraping it is possible to operate effectively with freezing temperatures of -40°C and colder, e.g. down to -100°C and preferably in the range of -50 to -60°C for achieving a good efficiency by the freezing down of the mass to about -15° through -22°C. It can only be confirmed, however, that the good results have been achieved by the use of the said modified continuous freezer, in which it is the worm itself that acts as the effective scraper tool.

[0014] There has been found no reason to assume that the aforementioned and in fact similarly important effect with respect to the preserving of the overrun should be particularly depending of the use of the discussed modified freezer, but.on the other hand it can be confirmed that the relevant good result can be achieved also by the use of this freezer, such that the combined result renders the said 'type' of process realizable in commercial practice.

[0015] The invention is illustrated in the drawing, in which:

Fig. 1 is a schematic diagram for illustrating the process, while
Fig. 2 is a schematic representation of a through-flow freezer according to the invention.

[0016] The processing system for producing extruded ice-cream products as schematically shown in Fig. 1 comprises a continuous freezer 2 which, from a supply 4, is supplied with 'mix' passing a pump 6 and a mixing chamber 8, in which the mix is mixed with air from a compressed air source 10 for achieving a overrun of traditionally some 100%. This ready made ice-cream substance is cooled in the continuous freezer 2 down to a temperature of approximately -5°C as fully conventional for a subsequent portioning out and shaping of the substance.

[0017] In connection with the invention, however, it is desirable to convey the cooled substance further through a continuous freezer 12 for a subsequent extrusion at a temperature of -12 to -25°C, such that the cut ice bodies can be packed for transfer directly to the freezing store. The freezer 12 should be positively conveying, i.e. it should comprise a conveyor worm 14 driven by a motor, which is here designated W in order to indicate that this driving will incur a certain supply of heat energy, partly for the conveying function itself and partly for the scraping work to be effected by the worm for scraping off the solid frozen ice-cream mass.

[0018] Owing to the associated increased viscosity of the mass it would be natural to use a somewhat enlarged dimension of the discharge pipe 18 compared with the supply pipe 16, but as mentioned it has been found that the final result of this is in fact unusable with respect to the overrun of the extruded mass. With the invention it has been found that this major problem can be solved by providing a discharge resistance R in the pipe 18. This resistance is relatively critical, inasfar as it should be noticeable for achieving the desired result with respect to the overrun, but not so noticeable that it gives rise to the conveying resistance in the freezer 12 increasing to a level at which the required conveying energy reveals itself as an unacceptable heat generation in the freezer.

[0019] This in itself is a noticeable problem, because it . may imply that it is very difficult to achieve the desired cooling of the ice-cream, practically no matter how much the freezer is cooled from the outside. This will be considered in more detail below.

[0020] First, it is important to note that normally the required flow resistance R should be statically or dynamically adjustable, as extensive tests have shown that the optimum resistance depends of various process parameters, including the formulation of the mix and the discharge temperature and capacity of the ice-cream. It is customary that in a given system there will be produced products with different formulations and process conditions, and the resistance R should be adjustable accordingly, based on gained experiences. Normally, as a standard, the pipe dimension at the discharge side of the freezer 12 should be slightly reduced, but the resistance should still be adjustable. This will be achievable by a differentiated partial heating of the narrower pipe, but preferably a controlled throttling valve or a pressure regulating valve should be used, for example a controllable constriction of a hose portion inserted in the dis-

charge pipe

[0021] Next, it is important that the continuous freezer 12 operates with a relatively very low temperature at the primary side, e.g. in the range of -40° to -100°C, and that it is made with a special geometry as far as the conveying/scraping worm is concerned, in connection with an equally unusually low rotational speed of the worm, preferably as low as 5-20 r.p.m.

[0022] The freezer unit 12,14 is indicated in more detail in Fig. 2 with the following designations of dimensions.

D1 = diameter of rotor core;
D2 = outer diameter of worm on this core;
D3 = inner diameter of surrounding freezing cylinder;
L = length of freezing cylinder and worm; and
P = pitch of worm.

[0023] With the invention the following relations are preferred:

$$\frac{L}{D3} = 5\text{-}10;$$

$$\frac{P}{D2} = \frac{150}{105} = 1\text{-}2;$$

$$\frac{D2}{D1} = \frac{105}{75\text{-}90} = 1{,}1\text{-}1{,}4 \text{ (height of worm winding).}$$

[0024] The pitch P should not necessarily be constant along the length L, as it may vary as desired for an optimized design and for reducing the ice-cream pressure during the conveying thereof through the freezer 12.

Claims

1. A method of effecting continuous production of an ice-cream substance, by-which the previously cooled, air holding substance is passed through a continuous freezer (2) for further cooling down to -12 - -15°C for subsequent extrusion, the substance being supplied to the freezer (2) through a pipe (16) of a first pipe dimensions **characterized in that** the ice-cream, downstream of the freezer (2,12), is passed through a pipe area which is narrower than said first pipe dimension, preferably in such a controllable manner that it is possible to adjust the associated flow resistance(R) for the ice-cream substance, this resistance (R) being adjusted to ensure a high overrun of the extruded substance.

2. A system for carrying out the method according to claim 1, comprising a continuous freezer (12) of the screw worm conveying and scraping type (14) with an infeed pipe (16) of a first pipe dimension and a discharge pipe (18) connected to an extrusion outlet for the frozen ice-cream, **characterized in that** the discharge pipe (18) exhibits a constriction to a dimension smaller than said first pipe. dimension, this constriction preferably being controllable for enabling its flowing resistance (R) towards the ice-cream to be adjusted.

3. A system according to claim 2, **characterized in that** the said constriction is a controllable unit for mechanically adjusting the cross sectional area of the constriction.

4. A system according to claim 2, charaterized in that the constriction is constituted by a pipe portion provided or connected with means for adjustably heating the pipe portion.

5. A system according to claim 2, in which the continuous freezer (12) is made as a cylinder with a driven screw rotor (14) for forcing the ice-cream through and out of the cylinder and for scraping off solid ice formations on the inside of- the cylinder, **characterized in that** the screw rotor (14) is connected with means (W) for rotating it with very low speed, viz. in the range of 5-20 r.p.m., and that the pitch (P) of the conveying and scraping worm of the screw rotor (14) is very large, viz. 1-2 times the outer diameter (d2) of the worm.

6. A system according to claim 5, **characterized in that** at the outside of the continuous freezer (12) there is an operation temperature of -40 - -100°C.

Patentansprüche

1. Verfahren zum Bewirken fortlaufender Herstellung einer Speiseeissubstanz, durch welches die zuvor gekühlte, luftenthaltende Substanz durch einen fortlaufenden Froster (2) zum weiter Herunterkühlen auf -12°C bis -15°C für anschließende Extrusion hindurch geleitet wird, wobei die Substanz durch eine Röhre (16) mit einer ersten Röhrendimension dem Froster (2) zugeführt wird, **dadurch gekennzeichnet, dass** das Speiseeis stromabwärts des Frosters (2, 12) durch einen Röhrenbereich, welcher enger als die erste Röhrenabmessung ist, bevorzugter Weise in so einer steuerbaren Weise hindurchgeleitet wird, dass es möglich ist, den zugehörigen Strömungswiderstand (R) für die Speiseeissubstanz anzupassen, wobei dieser Widerstand (R) angepasst wird, um einen hohen Aufschlag der extrudierten Substanz sicherzustellen.

2. System zum Durchführen des Verfahrens gemäß Anspruch 1, welches einen fortlaufenden Froster (12) der Schraubenschneckenförder- und Schabweise (14) mit einer Einlassröhre (16) der ersten

Röhrendimension und einer Abgaberöhre (18) hat, die an einen Extrusionsauslass für das gefrorene Speiseeis angeschlossen ist, **dadurch gekennzeichnet, dass** die Abgaberöhre (18) eine Einschnürung einer Dimension aufzeigt, die kleiner als die erste Röhrendimension ist, wobei diese Einschnürung bevorzugterweise steuerbar ist, um zu ermöglichen, dass ihr Fließwiderstand (R) gegen das Speiseeis angepasst wird.

3. System gemäß Anspruch 2, **dadurch gekennzeichnet, dass** die Einschnürung eine steuerbare Einheit zum mechanischen Anpassen der Querschnittsfläche der Einschnürung ist.

4. System gemäß Anspruch 2, **dadurch gekennzeichnet, dass** die Einschnürung durch einen Röhrenabschnitt gebildet wird, der mit Vorrichtungen zum anpassbaren Erhitzen des Röhrenabschnitts vergehen oder verbunden ist.

5. System gemäß Anspruch 2, in welchem der fortlaufende Froster (12) als ein Zylinder mit einem angetriebenen Schraubenrotor (14) zum Drücken des Speiseeis durch und aus dem Zylinder heraus und zum Abschaben fester Eisformationen an der Innenseite des Zylinders gefertigt ist, **dadurch gekennzeichnet, dass** der Schraubenrotor (14) mit Vorrichtungen (W) zum Drehen desselben mit sehr geringer Geschwindigkeit, nämlich in dem Bereich von 5 bis 20 U.p.M., verbunden ist und dass der Taktabstand (P) der Förder- und Schabschnecke des Schraubenrotors (14) sehr groß ist, nämlich ein bis zwei Mal der äußere Durchmesser (D2) der Schnecke.

6. System gemäß Anspruch 5, **dadurch gekennzeichnet, dass** an der Außenseite des fortlaufenden Frosters (12) eine Betriebstemperatur von -40°C bis -100°C herrscht.

Revendications

1. Procédé de production continue d'une substance de crème glacée, dans lequel la substance retenant l'air, précédemment refroidie passe dans un congélateur continu (2) pour y être de nouveau refroidie entre -12 et -15 °C en vue d'une extrusion ultérieure, la substance étant fournie au congélateur (2) par l'intermédiaire d'un tuyau (16) ayant une première dimension, **caractérisé en ce que** la crème glacée, en aval du congélateur (2, 12), passe par une zone de tuyau qui est plus étroite que ladite première dimension de tuyau, de préférence d'une manière contrôlée permettant de régler la résistance à l'écoulement (R) associée pour la substance de crème glacée, cette résistance (R) étant réglée pour garantir un excédent important de substance extrudée.

2. Système permettant de mettre en oeuvre le procédé selon la revendication 1, comprenant un congélateur continu (12) du type à convoyeur à vis sans fin et à racle (14) doté d'un tuyau d'alimentation (16) ayant une première dimension et d'un tuyau d'évacuation (18) raccordé à une sortie d'extrusion de la crème glacée congelée, **caractérisé en ce que** le tuyau d'évacuation (18) présente un étranglement ayant une dimension inférieure à ladite première dimension de tuyau, cet étranglement pouvant de préférence être contrôlé de façon à permettre un réglage de sa résistance à l'écoulement (R) vers la crème glacée.

3. Système selon la revendication 2, **caractérisé en ce que** ledit étranglement est une unité pouvant être commandée de façon à régler mécaniquement la superficie en coupe de l'étranglement.

4. Système selon la revendication 2, **caractérisé en ce que** l'étranglement est constitué d'une portion de tuyau munie de ou raccordée par un moyen permettant de chauffer de manière réglable la portion de tuyau.

5. Système selon la revendication 2, dans lequel le congélateur continu (12) est construit comme un cylindre muni d'une vis commandée (14) destinée à faire entrer et sortir la crème glacée dans et hors du cylindre et à racler les formations solides de glace à l'intérieur du cylindre, **caractérisé en ce que** la vis commandée (14) est reliée à un moyen (W) afin de le faire tourner à une vitesse très lente, à savoir entre 5 et 20 t/min., et **en ce que** le pas (P) de la vis sans fin de transport et de raclage de la vis commandée (14) est très grand, à savoir 1 à 2 fois le diamètre extérieur (d2) de la vis sans fin.

6. Système selon la revendication 5, **caractérisé en ce que** la température de fonctionnement, à l'extérieur du congélateur continu (12), est comprise entre -40 et -100 °C.

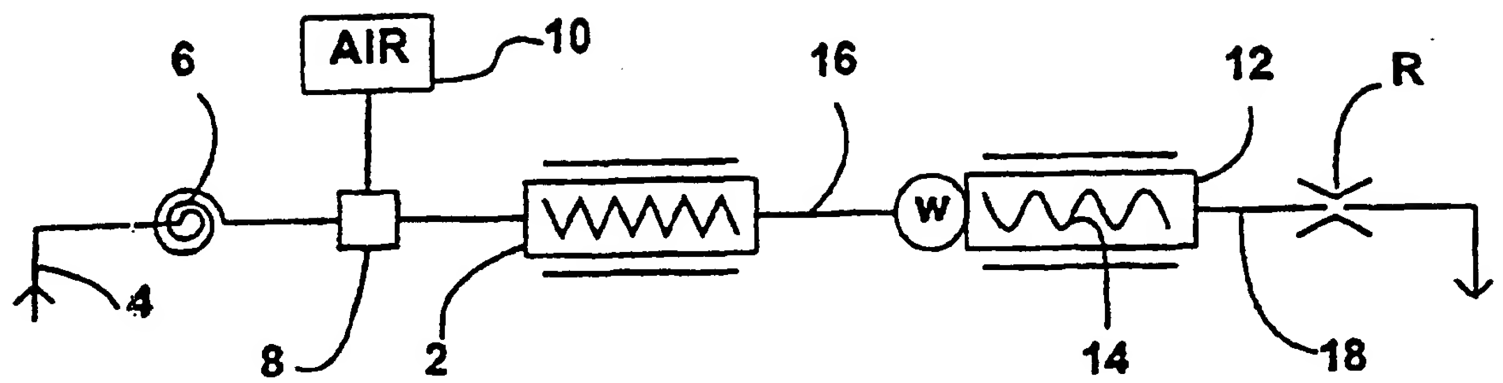

Fig.1

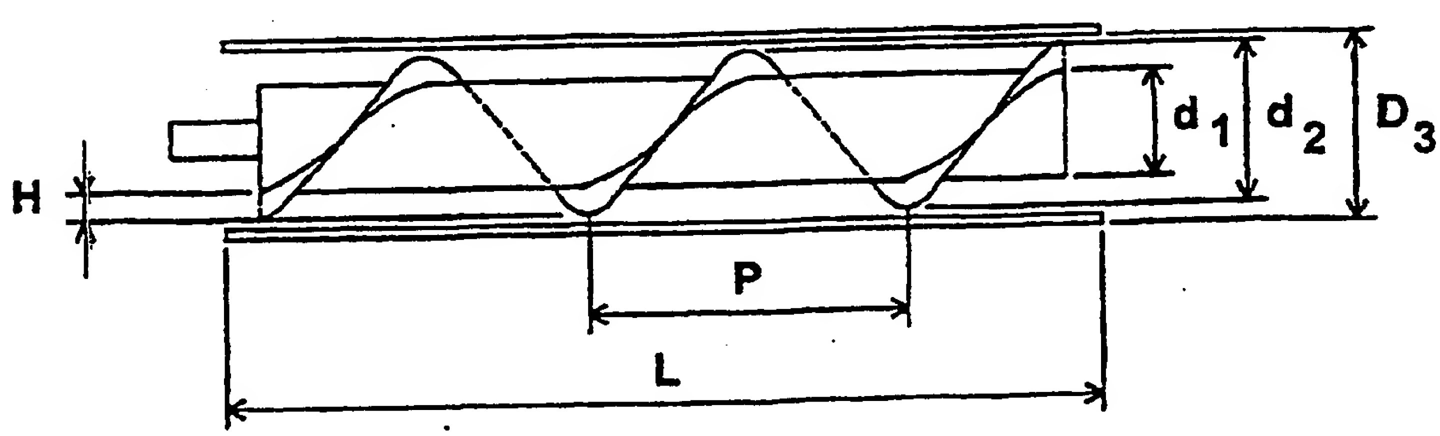

Fig.2